SMART SCHOOLS:

IMPLEMENTATION OF SENSORY TECHNOLOGY AT HAILEYBURY COLLEGE

Version 1.0

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EXECUTIVE SUMMARY

The following document summarises how the use of *'sensory systems'* can be beneficial to the quality of education delivered at Haileybury college across all campuses and how it can improve the quality of education and safety of children.

The intended cost of the project is projected to be **$436,480 - $359,040** depending on the quality of the equipment and is expected to be completed in **22 weeks from January 11th, 2021 to June 14th, 2021.** If multiple contractors are hired to each campus location to save Haileybury college between **20-60% of utility costs**. With potential savings between ***$45,066 to $135,199*** per annum and the system is expected to **pay for itself within 2-5 years.**

The implementation of sensors within the school aims to reduce utility costs across all the campuses as well as provide a positive impact on the environment through the reduction of the school's carbon footprint.

The strategy of innovation being used is radical and routine by synthesizing technology that is being used already in other industries such as universities and manufacturing initiation and applying it to a school setting.

Key Sensors;

- Proximity/motion Sensors

- Radio-Frequency Identification Sensor

Expected Benefits;

- Increased student/staff safety

- Increased product value

- Reduction of utility costs

- Reduction of carbon emissions

Possible Limitations;

- Ethical/Privacy concerns

- Installation costs

- Sensor capabilities

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1 INTRODUCTION

The 'Industrial Internet of Things' is the next revolution following the Internet Revolution. Internet of Things is constructed around the idea of utilizing wireless and information technology in a way to increase efficiency within a business, enhance protection of digital information, moving servers, and other back end programs off-site by implementing clouds within an organization and ultimately reducing costs (Tan and Wang, 2010). The industrial Internet n draws focus on utilizing the internet's capabilities by practically implementing within organizations ranging from procurement, farming, finance and education (Mazhelis, Luoma, and Warma, 2012). Technology that is implemented in the organization as aforementioned includes; the uses of artificial intelligence (self-driving cars), cloud systems (storage of data), serverless computing (outsourcing back end development) and sensory technology (motion sensors) (Aazam Zeadally and Harras, 2018).

Educational Institutions in the Australian public and private school systems have already implemented various Internet of Things (IoT) across Australia (Kiryakova, Yordanova and Angelova, 2017). IoT which has already been implemented in schools such as the use of computers and portable devices, application such as skype and zoom, information-based platforms including blackboard and go2 have resulted in increased student engagement, created an increased mobile learning reach, improved student efficiency, provides students with a safer learning environment and increased student success (Laferrière, Hamel and Searson, 2013).

Haileybury college has implemented several of the IoTs listed within their educational institution including Zoom, Blackboard, and Stile (learning-based application). Haileybury College is yet to utilize IoT associated with creating a 'smart environment'. A smart environment is one that draws focus on increased efficiency and a focus on the preservation of the environment resulting in reduced costs (Castro, Jara and Skarmeta, 2013). A smart environment can be created at Haileybury college using sensory technology. A sensor can be defined as a device that has an input of information responds by providing an output (response). Sensors can be used to reduce the cost of utilities imposed on an organization and increase the efficiency and quality of student learning created by the output of the sensors (Barbour and Schmidt, 2001).

2 PROJECT SCOPE

2.1 Scope Statement

The aim is to become the leading smart school in Australia by implementing sensors across all Haileybury college campuses and increase product quality by providing parents with a better service by improved student security and a more technologically advanced school. The implementation of sensors also aims to reduce utility costs for Haileybury college across all the schools. The expected cost of the project varies depending on which campuses are approved to implement the sensor technology. The sensor technology aims to reduce electricity costs by %20-%60 (Bakker, Van De Voort and Rosemann, A. 2017) The estimated figure includes the implementation of both the RFDI door sensors and light-sensitive motion sensors *at all campuses* (Berwick, Keysborough, Brighton and Rendall). Cost estimations are expected to vary. The predicted cost is expected to be between **$436,480 - $359,040** and predicted to save ***$45,066 to $135,199*** per annum on electricity costs. The proposed duration of the project is dependent on the board members' approval if the project is approved by December 2020, Installation of the sensors is set to begin **January 11th, 2021 to June 14th, 2021.**

Risks associated with the project include the cost of the system to be installed and programmed, parental concern over student's personal information and maintenance costs if the system were to fail. A trial period involving one of the buildings at Haileybury Keysborough where students and staff will be able to provide feedback on their attitudes towards the system via anonymous questionnaire online or drop-box. Upon completion of the trial period, all feedback can be reviewed as well as the cost to run the system. Based on the evaluation it can be determined if sensor technology can be implemented through Haileybury Keysborough.

2.2 Key project Objectives and Goals

Key details and objectives that are expected to arise from the implementation of the project are as follows:

- Become the leading Smart school in Australia.
- Reduced utility costs
- Increased student/staff safety
- Improved learning environments
- Improved classroom quality and efficiency
- Reduced carbon emissions

Project dependencies include:

- Cost of the system
- Approval by the Haileybury Board
- Installation time
- Research and Design

Project Assumptions include:

- Necessary Budget/Finance
- Acceptance of the Proposal
- Parental/Staff/Student Acceptance
- All buildings are capable of sensor installation

Project Limits include:

- Project Budget
- Stakeholder engagement
- Complaints (parents/staff/students)
- Project Approval

Project Assumptions:

- Immediate availability of funding
- The current lighting system is compatible with the new system
- All rooms have LED downlights
- The current RFID system is installed at Haileybury college

2.3 Proposal Questions and Review

Q. What will happen if a student or staff members lose their key pass to get into their office/classroom?

A. The benefit of having a key pass is that it can be wiped and reissued when maintenance is notified straight away. Compared to having a master key that we currently have, if a key is lost then all the locks need to be replaced within the school to prevent a security breach. Using a key pass is safer than using a traditional key.

Q. If the lighting is sensor activated by motion, how will I turn off the lights when I am in there and need to use the projector.

A. The switches in the classroom will remain on the wall. The wall switches would be expected to behave like a manual override to the sensors, as a result turning off the sensors completely and hence the lights.

Q. Is there any breach of privacy using proximity sensors to keep track of staff/students moving around certain areas of the school at certain times?

A. The proximity sensors do not save any personal information of individuals and do not behave as a security camera. The proximity sensors merely *count* the number of people to pass within its range. This information on counting the number of people that pass through the library or specific gates can help provide information on how many people are in the school at one time, the number of people entering the library at specific hours. With this data greater efficiency and uses of the library can be improved as well as traffic flow in and out of the school in peak times.

3 SCHEDULE AND TIME MANAGEMENT

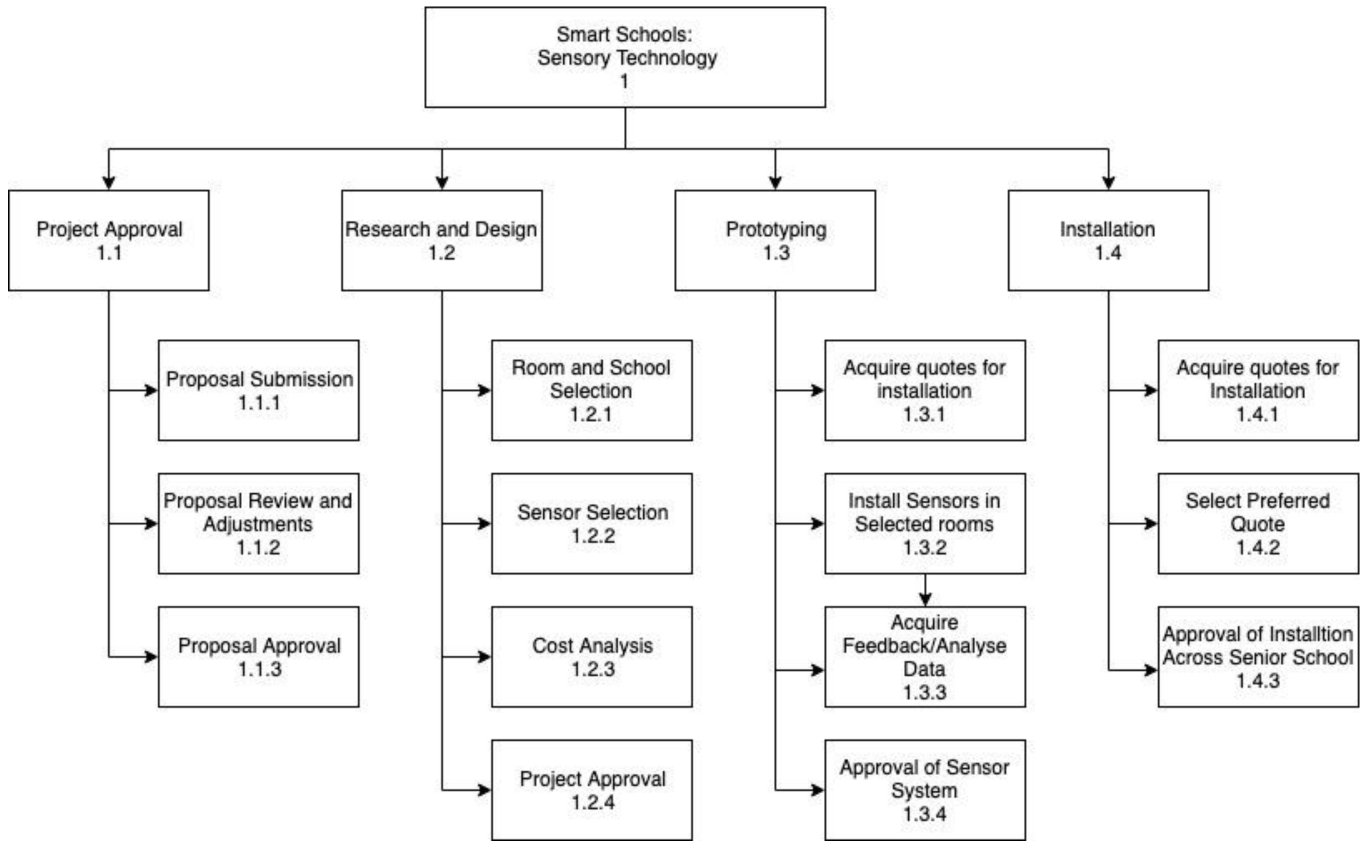
3.1 Project Tasks

PROJECT TITLE	SMART SCHOOLS: SENSORY TECHNOLOGY	COMPANY NAME	HAILEYBURY COLLEGE
DEVISED BY	CAMERON BEVERIDGE	COMMENCEMENT DATE	8/1/2021

1 Smart Schools: Sensory Technology
- 1.1 Project Approval
  - 1.1.1 Proposal Submission
  - 1.1.2 Proposal Review and Adjustments
  - 1.1.3 Proposal Approval
- 1.2 Research and Design
  - 1.2.1 Room and School Selection
  - 1.2.2 Sensor selection
  - 1.2.3 Cost Analysis
  - 1.2.4 Project Approval
- 1.3 Prototyping
  - 1.3.1 Acquire Quotes for Installation
  - 1.3.2 Install sensors in selected rooms
  - 1.3.3 Acquire Feedback/Analyse Data
  - 1.3.4 Approval of Sensor System
- 1.4 Installation
  - 1.4.1 Acquire Quotes for Installation
  - 1.4.2 Select Preferred Quote
  - 1.4.3 Approval for Installation Across Senior School

3.2 Work Break Down Structure

The following image illustrates the packages and tasks that are required to implement the proposed sensor system



4 MARKET RESEARCH

4.1 Research Data

All market research is secondary data. All the figures are provided by Universities and businesses that have shared their findings openly. Other secondary data has been based on research and peer-reviewed papers. Primary research conducted by Cameron Beveridge included interviewing respective teachers from various Melbourne schools. It is recommended that Haileybury college produces its primary research examining their consumer's perceptions of the possible alterations to the schools as well as analyzing their current utility costs.

4.2 Consumer perceptions

Paetz (2012) found Attitudes towards smart home technology involving sensors were positively received by those who used it. The positive attitudes resulted from the reduced energy consumption and the cut to energy costs as participants struggled to change their lifestyles to save money. Demiris et al (2004) study on adult’s attitudes towards smart home technologies such as sensors was also found where all participants that partook in the study had an overall positive attitude towards smart devices and smart sensors. Nugroho and Haryani’s (2016) study examining generation X and Y’s perception towards IoT was found to be positive due to their understanding and involvement with smart technology already (phones and pads). User's perceptions with the benefits of IoT in homes is was found to be dependent on the associated risks and user-friendliness of the technology. Where participants who found it difficult to operate the technology were less accepting of the technology (Schuhaiber and Mashal, 2019). Young et al (2010) found that 30% of participants were concerned about their purchase and the impact it had on the environment and believed that going green requires time and space in everyone's lives. TD Bankpoll's (2011) survey found that 88% of participants cared about their impact on the environment and another 37% said they have been swayed on purchasing a product from a company based on their environmental impact. Based on previous research, there is large support and a portion of consumers that are influenced by a product's impact on the environment. This is potentially an untapped market and selling point for Haileybury education.

4.3 Case Studies

University of California, Berkley, USA

The University of California (Berkeley) is one of the top-ranked universities in America for chemistry and environment/ecology. The University of California has implemented sensory technology into its University back in 2006 following the implementation of its '*UC Berkeley’s Strategic Energy Plan* (sustainability.berkley.edu, 2020).

The sensor technology used by UC;

- Lower wattage, motion sensor-controlled lighting in gyms and facilities.
- Motion-sensing wireless lighting in offices and rooms.
- replacement of 1,000-watt lighting with high-efficiency induction lighting.

- 2006 to 2010, UC saved 10,000,000 kilowatt-hours of saving per year (approximately 1 million dollars).

Citi, Canary Wharf, UK
Citi, Canary Wharf located in the United Kingdom implemented a smart control system that was focused on light-sensitive sensors. The lights would dim according to the amount of natural light received by the sensors as well as occupancy controlled (motion sensors). Citi's goal was to increase energy efficiency by 20% by 2015 compared to 2005 figures (Phillips, 2020). With the use of smart lighting and LED lights the Citi was able to;

- Increase efficiency
- Reduce CO2 emissions
- Delivered energy savings for approximately 45%

Bosch, Munich, Germany
BOSCH is a global leader in engineering and innovation based in Germany. After 125 years of innovation BOSCH's office in Munich has become committed to supporting the environment and shifted to smart lighting solutions. The office space is 240 square meters. The office implemented multi-sensors that respond to different light sensitivities allowing for additional energy savings (Phillips, 2020).
With the multi-sensor lights BOSCH was able to;

- Reduced electricity consumption by 52%
- Energy savings up to 72%
- Annual CO2 emissions reduced by 8 tonnes
- Cost savings of € 126 per month

Several other methods are used in conjunction with sensor lights. Other features of LED lighting and automated blinds to help manage thermal heating throughout the building. Other notable examples include the HSBC tower (40,000 meters squared) in Mexico City which managed to achieve the LEED (Leadership in Energy and Environmental Design) certification awarded for energy savings, water efficiency, CO2 emissions reduction, improved indoor environmental quality. This was achieved by implementing similar systems (Phillips, 2020).

4.5 Competitor Analysis

Scotch College
Scotch College is a top tier private school in Victoria. The school is renowned for its academia, extracurricular actives such as rowing and pipes and drums. A long-time competitor with Haileybury college to be one of the most affluent schools in Australia. After liaising with staff at Scotch college, sources have stated that there are no lighting sensor systems and or Radio Frequency Identification scanners implemented on classroom doors and offices. Due to the age of the building's sources suggest that newer buildings in the Design department are considering implementing technology into newer buildings in the future.

Melbourne High

Melbourne High is Melbourne's leading all-boys public school. The school boasts academic results with select entry to the school based on students' marks with a focus on science and mathematics. Having worked at the school personally and contacting the older staff, the school is yet to implement such technology within the school. Due to the age of the buildings and use of fluorescent lights the school would have difficulties installing sensor lights and Radiofrequency Identification sensors.

St. Kevins

St Kevins is a roman catholic all-boys private school that claims be developed on a strong academic tradition where students are encouraged to take responsibility for learning in an environment that prides themselves on the value knowledge. A consultation with a science staff member at St. Kevins claims that their science building has already implemented sensory lights in the science department pushing green technology however the remainder of the school's buildings are outdated and yet to implement sensor technology. The school has not used any Radiofrequency Identification scanners on any of their offices or classrooms.

Melbourne Grammar School

Melbourne Grammar School is one of Victoria's most prestigious private schools building on the proud tradition which fosters excellence in their students through meaningful and gulling education across 3 campuses. Staff from the mathematics team have detailed the implementation of light sensors throughout their senior school located in the heart of Melbourne. The buildings that currently have sensor lights are in their newer buildings facing issues with older buildings not being compatible. The school has begun to implement Radio Frequency Identification Scanners for improved security into Labs and administrative offices.

4.6 Research Analysis

Research suggests that the use of sensor technology in Secondary Australian schools is yet to be utilized to its full potential. No known private schools have implemented sensor technology throughout the entirety of their schools or all of their campuses. Solar and zoom and other ICT devices are being used by other schools and can be found on the internet via the school's website. However, no information on their website boasts state of the art sensor technology being implemented in their school to support the environment and quality of education. There is a hole that is not filled by other schools. Haileybury is at the forefront of innovation and entrepreneurship. The hole in the market for sensor technology in Secondary schools can be led by Haileybury college to become the leading Smart School in the country using technology.

5 SENSOR ANALYSIS

The potential application for sensors is broad due to their function and output capacity in real-time. Sensors vary based on their primary input ranging from light, touch, gases, colour, and temperature (Potyrailo, 2016). The diversity of sensors allows for a variety of possible applications within a school that can improve student safety, save money for the organization as well as have a positive impact on the environment.

The following sensors and applications are as follows;

5.1 Motion sensors

Motion sensors can measure a person's position, velocity, and acceleration. The motions sensors capture the input motions and respond with an output. The motion sensors are expected to be used around the school in different contexts. The motion sensors will activate lights and then deactivate them when a person leaves the area/room saving money and reducing the carbon footprint (Li, Yu, Deng, Luo, Ming and Yan, 2017). This includes the lighting of paths across the school on special events and evenings as well as classrooms and offices. The application of motion senses prevents wastage of power when people forget to turn lights on and off.

Applications

- Classroom
- Offices
- Pathway lighting
- Gyms
-Dorm rooms (Haileybury China)

Limitations

- passive motion sensors do not operate above 35 degrees
-Time limit on light activation

5.2 Proximity sensor

Proximity sensors detect the movement of objects using an electromagnetic field. When an individual passes a proximity sensor within the desired range, a response is induced (Kim, Mechitov, Choi and Ham, 2005). Proximity sensors can be very beneficial to the school. Haileybury College is the largest private school in Australia. Proximity sensors can count and track the movement of people throughout the school. At all times the school will know how many people are on campus at any one time. The sensors can also be used to aid in student movement around the school counting the number of a student walking a particular path at any given time to improve the efficiency of facilities during peak movement times such as the library.

Applications

- Can behave as an alarm system

- Determine the total number of personnel that enters and leaves the school
- Provide data on improving the efficiency of services such as bathrooms, library, and pathways
- Improve traffic efficiency

Limitations
- Proximity sensors maybe
- Insensitive to the slow motion of movement

5.3 RFID (Radio-Frequency Identification) Sensors

Radio-Frequency Identification Sensors are commonly used with key card passes in hotels and other secured facilities. This technology can be implemented within the school grounds (Deenadayalan, Murali and Baanupriya, 2012). The science department works with various chemicals and requires access to authorized personnel only. The current system for opening doors is with master keys given to all teachers. If one key is lost all the keys must be returned and locks replaced. Using a key card system will allow admin to disabled cards electronically rather than recall entire sets. This system can also be used to give students and parents access to school grounds, preventing unwanted visitors from the school that could cause harm to staff and students. This system can also be used to monitor student movements through the school to ensure classes are attended.

Applications
- Restricting Access
- Removal of key and lock systems
- Personal Identification
- Dorm rooms (Haileybury China)

Limitations
- Radio frequencies at high power is harmful to people
- Radio frequency does not penetrate metal
- Insensitive to slow motion of movement

6 RISKS AND LIMITATIONS

Several risks and limitations have been identified with the implementation of various sensors around the school. Each risk and limitation are analyzed and explained in detail with possible preventive measures to reduce/remove the risk/limitation.

The identified risks are as follows;

6.1 Privacy/Personal Details

Privacy is a serious concern to students, staff, and parents concerning emerging technologies. A substantial amount of technology now uses facial recognition, finger scanners and the use of personal passwords to access personal devices and accounts. Identity theft is becoming more prevalent with new emerging technologies, especially regarding data mining. Leaking personal information from platforms such as Facebook has raised concerns with the individual's trust in sharing personal information. As a result of this, people may be concerned that motion, proximity, and RFID sensors are collecting personal information of individuals.

Countermeasure

The sensors that are being proposed are activated via the detection of infrared energy. The sensors do not record any video footage, nor do they take pictures of students. This means that all individuals will maintain their privacy within school grounds. Students will also be informed of classrooms that contain sensors, so they are aware of the technology that is being used in the school to remove the fear of being spied on by the school or the harvesting of their personal information (Elwell and Himonas, Cooper Wiring Devices Inc, 2008).

6.2 Hacking

Potential hacking attacks are another perceived risk with the installment of sensor technology. Hacking is the process in which unauthorized personnel finds weakened in a computer system to gain access and tamper with personnel information or systems. Perceived risk is that the system may give hackers another way into the Haileybury system giving them access to personal information of students and staff.

Counter Measure

There is no reason for hackers to tamper with the sensor systems that are being proposed. In a worst-case scenario, the sensors will be deactivated. The sensor systems also do not store personal information of any staff, students or parents to access rooms (Garfinkel, Juels, and Pappu, 2005).

6.3 Installation Costs

New developments in technology are can be perceived as expensive and unnecessary. Purchasing sensors and then having them installed across all the offices and classrooms in the school is going to have an intimidating setup cost. The installation will require hours of manual labor. This includes the cost of the set up to purchase ID cards that can be used to open doors to classrooms and offices.

Countermeasure

The initial set up cost is expected to be expensive. If the immediate funds are not available to roll out the system across the entire school, set up can occur incrementally, starting with senior school and then middle school at a later date. The system is also expected to pay for itself. Based on the values provided, Haileybury is expected to save 20-60% on the current electrical bill. Depending on Haileybury’s current usage will determine when the system will pay for itself.

6.4 Lost Key Cards

If a staff member is to lose one of their access cards to their office or room, there is a concern that if in the wrong hands, a student of non-authorized person could gain access to offices and classrooms. This is a safety and privacy issue. Many issues can arise from having a key card that grants access to all areas of the school. Traditionally with the original lock and key method, if a key was lost, all the keys must be recalled, and all the locks must be changed. This is a costly process.

Countermeasure

Unlike the traditional lock and key method, the key cards operate like that of a hotel key. The information can be wiped remotely to prevent any unauthorized person from having access to any private spaces. The result of this means that if a key is lost the school does not have to replace all the keys and locks saving money and this also prevents any security breaches by canceling the card immediately after being lost (Zhou and Stewart, 2007).

7 COST ANALYSIS

The following cost analysis is based on estimations from trade professionals outside of the Haileybury payroll. These figures are susceptible to change. The following figures are based on a series of assumptions about the number of staff members and classroom numbers.

****Due to lack of personal information about each of the schools due to my authorization estimations of staff and buildings were made to approximate costs.***

All estimations are based on;

- 5-day work week (Monday to Friday)
- 8 Workday (7 hours paid, 1-hour unpaid lunch break)
- 1 laborer
- Estimated time to install 1 sensor requires 3 hours labor
- Installation time to install 1 new lock requires 1 hour of labor
- Estimations are based on contractor quotes and experience

Assumptions include:

- All rooms are light sensor compatible (LED downlights)
- Haileybury already has an RFID system installed (ID scanner cards) in use.
- Each building has 8 rooms (includes offices and classrooms)
- The number of buildings at each campus is based on the campus maps provided by Haileybury college

7.1 Estimated Cost to replace Keysborough Campus Locks

The estimated cost to replace the senior school locks was based on a lost key by a single staff member, 2019, which resulted in all the staff keys and classroom and office locks to be replaced schoolwide.

Number of buildings on campus = 16
Number of rooms 128
Estimated Keysborough Teaching Staff = 252

Item	Cost Per Unit/per hour (AUD)	Number of units/Hours worked	Total Cost (AUD)
Locksmith	$70	128	$ 8,960
Restricted key	$15	252	$3,780
Locks	$100	128	$12,800
Total Cost			**$ 25,540**

7.2 Haileybury College Keysborough Campus Sensor System Cost Estimation

Number of buildings on campus = 16
Estimated number of rooms/offices = 128

Item	Cost per/h (AUD)	Total hours/units	Total Cost (AUD)
Electrician	$70	768	$53,760
Ultrasonic motion sensor	$120 - 50	128	$15,360 – 6,400
RFID sensor	$700 - 550	128	$89,600 – 70,400
Total Cost			**$158,720 – 130,560**

Estimated completion time

- 110 business days / 22 weeks

7.3 Haileybury College Brighton Campus Sensor System Cost Estimation

Number Buildings on campus = 10
Estimated number of rooms/offices = 80

Item	Cost per/h (AUD)	Total hours/units	Total Cost (AUD)
Electrician	$70	480	$33,600
Ultrasonic motion sensor	$120 - 50	80	$ 9,600 – 4,000
RFID sensor	$700 - 550	80	$ 56,000 – 44,000
Total Cost			**$ 99,200 – 81,600**

Estimated completion time

-69 business days / 1 week.

7.4 Haileybury College Berwick Campus Sensor system Cost Estimation

Number of buildings on campus = 11
Estimated number of rooms = 88

Item	Cost per/h (AUD)	Total hours/units	Total Cost (AUD)
Electrician	$70	528	$ 36,960
Ultrasonic motion sensor	$120 - 50	88	$10,560 – 4,400
RFID sensor	$700 - 550	88	$ 61,600 – 48,400
Total Cost			**$109,120 – 89,760**

Estimated completion time

-66 business days / 15 weeks

7.5 Haileybury College Rendall Campus Sensor system Cost Estimation

Estimated Number of buildings on campus =7
Estimated Number of rooms/offices = 56

Item	Cost per/h (AUD)	Total hours/units	Total Cost (AUD)
Electrician	$70	336	$ 23,520
Ultrasonic motion sensor	$120 - 50	56	$6,720 – 2,800
RFID sensor	$700 - 550	56	$39,200 – 30,800
Total Cost			**$ 69,440 – 57,120**

Estimated completion time

- 48 business days / 10 weeks

7.6 Estimated Project Totals

The following projected costs and duration is based on the assumptions aforementioned and the total accumulation of predicted costs for each campus.

Total Predicted Project Cost	**$436,480 - $359,040**
Total Project Duration	**293 business days/59 weeks**

7.7 Business Savings

The following table illustrates the current estimated electrical costs of all the campuses combined and the predicted new electrical costs after sensory system implementation.

Current Estimated Electrical Cost	**$225,332**
Approximate Savings	**$45,066 – $135,199**
Sensor System Estimated Electrical Cost	**$180,266 – $90,133**

**Due to the lack of information on energy used by the school and each school's utility costs, the estimated value would be required to be readjusted accordingly.*

Based on an article stating that Queensland government schools' electrical bills have reached $67.6 million, across 1200 schools (Caldwell, 2017). The average electricity costs were calculated to be $56,333. Based on previous research the sensor lights are expected to save between 20% and 60% of electrical costs. Assuming Haileybury's electrical costs are $56,333 per campus per annum, ***the total electrical cost is $225,332*** to power all the campuses. Haileybury can ***save approximately $45,066 to $135,199*** on their electricity costs. Based on the cost analysis and savings analysis, it would take approximately 2 to 5 years for the sensory system to pay for itself and then Haileybury would be expected to make saving money after that period.

7.8 Cost Analysis

Due to the lack of information about Haileybury college's overall utility cost, no estimation can be made on the amount of money that could be potentially saved. Working based on research provided, Haileybury college could save between **20-60%** on their energy costs. To implement changes across all the Haileybury College campuses listed the estimated project is expected to cost between **$436,480 - $359,040** if sensors are implemented at all campuses. The expected duration for the installation of the sensors at all campuses simultaneously would be expected to take up to **22 weeks** providing there were one electrician making installments at each location. This timeframe can be drastically reduced by increasing the number of laborers. Haileybury College is an international institution with 6 campuses. It is expected that Haileybury college uses a substantial amount of energy and would have substantially high utility costs. ***Saving 20-60%*** on electricity bills could save Haileybury College ***$45,066 to $135,199 per annum.*** *The sensor system is expected to pay or itself **2-5 years** later*. The replacement of the current lock and key system is costly and risky. The current keys can be copied and used at any time. It is estimated that the cost to replace all the keys and locks in senior school alone could be up to ***$25,000 every time a key is lost***. In the event of losing an RFID key card, the cost could be up to $5 or less depending on the card, saving the school thousands and ensuring student safety.

8 IMPLEMENTATIONS

Several processes will be required before implementation of the various sensory systems within Haileybury college due to governing bodies internal and external to the school (Robertson, Grad, Fluck and Web, 2006). The first process is research and design, predicted cost and budgeting of the various systems, approval by the board and CEO of Haileybury College, prototyping and trial periods, interpretation of results from staff and students and last lastly the installation of the sensory system across the Haileybury College campuses.

8.1 Research and Design

Research and design and essential steps into the implementation of the sensory system. Research and design are aimed at determining whether or not there is a market for the sensory stem and if it is going to add value to the product before spending copious amounts of money implementing a system that is not required (Woodruff, 1997). Research into the system will focus predominately on the current costs of utilities concerning electricity consumption. Other research will be aimed at the necessity of key passes based on previous incidents with strangers entering the school and students entering unwanted areas. With the design, the sensory systems must remain concealed to maintain the school's aesthetic.

- collaboration with students, teachers, and parents
  - Survey, Questionnaire
  - answer any concerning questions
  - sensory placements in the room
  - compare sensor brands

8.2 Budget Analysis

A major factor in determining whether or not the sensory system is implemented is dependent on the cost-benefit analysis of the project (Rajenen, 2003). It is paramount that the system acknowledges all hidden costs and that the installation of the sensory system will save the company money in the long term. This also relates to the value being added to the school's overall product of education. The intent of adding a safer security system can be seen as an added value to the product, as a result, an increase in the product price per student to attend the school.

- compare quotes from various providers.
- assess maintenance costs
- project saving projection
- available funds

8.3 Board Approval

Board approval of the plans will be required before the prototyping and trial phase of the various sensory systems. It isn't uncommon for bureaucracy and administration to become apparent in slowing down the process of and implementation of projects due to the redrafting of plans, incorrect documentation and project reviews (Al-Qahtani and IBN-METHHEB, 1999). Following the proposed evidence of market research, design and cost analysis of the project to the board and the money and value that can be added to the product is intended to seek approval swiftly for the implementation process to continue.

- The proposal received by the Deputy Principal and reviewed
- The proposal is reviewed by the CEO and Board
- The proposal is approved/rejected

8.4 Prototyping and Trial Phase

The prototyping and trial phase is expected to run a year to determine the amount of money saved by implementing the sensors. The trial phase will only be implemented on one of the campuses. Prototyping and trials are crucial in the functionality and effectiveness of the sensors. This period of prototyping allows for inputs from the students and employees to observe the impact of the system and functionality (Guimaraes and Saraph, 1991). Feedback from employees and students is detrimental to the practicality of the technology (Buchenau and Suri, 2000). Feedback is expected to be given as an online survey using a Likert Scale (Joshi, Kale, Chande and Pal, 2015). Based on the results of the survey and the money saved will determine whether or not the sensor system will be implemented.

- The sensor system is implemented in selected rooms across the senior school
- Feedback and surveys are reviewed from staff, students and parents
- Reduction of utility costs are reviewed
- The sensor system is reviewed at the end of the trial period for approval/rejection

8. 5 Installation

Installation of the system is expected to be rolled out during the summer holiday period from **January 11th, 2021 to June 14th, 2021.** Before these dates, contractors and tender processes would be completed and ready to start from December 15th. No need for procurement as all parts will be sourced by the contractor. All relating to the system will operate via serverless computing, outsourcing backend developers to the technology if there are any issues with the technology. The system will be monitored for a year and the system reviewed again examining surveys and utility costs.

- Installation goes to tender for lowest price
- final quote is reviewed and approved
- Installation occurs at Haileybury Keysborough
- Installation at other campuses occur at a later date

9 PROJECT REVIEW

The project aims to increase the student's quality of education, safety, reduce utility cost and push the organization into the direction of being one of Australia's first and leading smart schools. This is to be achieved by implementing various sensors that are sensitive to proximity, motion, and RFID. The project aims to target a new market of consumers who are interested in quality education and technologically advanced school with an awareness of their environmental impact. Using radical and routine innovation implementing technology that is currently being used in other industries reduces the risk of implementing the technology within the school. Prototyping and trialing the system across one school before implementing the sensors across all campuses aims to reduce the risk of the project. Utilizing emerging technology such as sensor technology can increase the overall product value of the school being offered to parents as well as save the school thousands of dollars yearly whilst reducing the school’s environmental impact.

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